

PROGRESS OF ECONOMIC AND SCIENTIFIC AGROSTOLOGY.

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DEFINITION OF AGROSTOLOGY.

The science of agrostology, strictly speaking, relates only to the true grasses, and an agrostologist is one who has made a special study of these plants; but in the present paper the term is used in a broad sense, and embraces not only the true grasses, but all other pasture and fodder plants. In this broad sense the subject becomes one of the greatest economic importance, in which every citizen of the United States is more or less directly interested; but only its more salient features can be considered in this paper, many interesting minor facts being of necessity wholly omitted. In the present treatment of the subject it has been found convenient to divide it into two parts: First, economic, or applied, agrostology; second, scientific, or systematic, agrostology.

ECONOMIC, OR APPLIED, AGROSTOLOGY.

CONDITIONS PRIOR TO THE BEGINNING OF THE CENTURY.

Prior to 1800 practically nothing had been done in this country in the cultivation of grasses and forage crops. There were comparatively few farms, and the food supply of cattle and horses was chiefly furnished by the natural growth of the indigenous grasses. The great grazing regions of the West were then unknown, and the almost boundless capacity of this country to support cattle of all kinds was not even suspected. The best known hay and pasture grasses were not unknown in those days; timothy, redtop, tall meadow oat grass, orchard grass, crested dog's-tail; and meadow foxtail had been frequently mentioned by agricultural writers for fifty years or more. Schreber, in his great work on grasses, published in 1769, minutely describes and illustrates all the species just mentioned, besides many others, including the now popular smooth brome grass; he notes, too, the special characteristics of each grass, the kind of soil to which it is adapted, and its agricultural value. It is a curious fact, noted also by Schreber, that timothy, a native of Europe, was introduced into cultivation in Europe through seed secured from this country.

CONDITIONS DURING SEVENTY-FIVE YEARS OF THE CENTURY.

Although at the beginning of the present century the list of forage grasses contained many names, very few had been taken up by American farmers; in fact, it does not appear that during the first half of

the century any marked progress had been made in the way of cultivating new or improved varieties. A few of the leguminous plants began to attract attention, but the farmers throughout the New England and Middle States were mostly content with timothy and redtop or timothy and clover and apparently cared for little else. The value

of clovers and leguminous crops generally for improving the soil was recognized by the more progressive farmers, and improved farming methods were beginning to be practiced by the more intelligent. In the South little attention was paid to grasses, and the planters imported most of their hay supply from the North. The common cattle found sustenance in the natural herbage, and crab grass, the poor man's hay, was as common then as it is now. In the West no attention whatever was paid to the cultivation of forage crops, the rich and abundant growth of grasses which everywhere covered the country at that time seeming to offer an inexhaustible supply for all grazing animals.

"Grasses for the South," by Rev. C. W. Howard, is the subject of a valuable paper published in the Agricultural Report of the Patent Office



FIG. 5.—Big blue stem (*Andropogon provincialis*): a, a pair of spikelets; b, first empty glume; c, second empty glume; d, third glume; e, fourth, or flowering, glume; f, palea; g, lodicules.

for 1860. Thirty-one varieties of grasses and forage plants suited to the South are described, and in the same paper fifteen economic grasses of Texas are described by Mr. G. Lincecum. The laying down of meadows and pastures and the management of grass lands are also fully discussed.

In 1869 the Superintendent of Gardens and Grounds of the Department of Agriculture, Mr. William Saunders, started a grass garden upon the Department grounds, in which fifty-one varieties of grasses and forage plants were cultivated. The results obtained the first season were published in the Report of the Commissioner of Agriculture for

• 1869. Further notes in regard to these experiments by Mr. Saunders appear in the Report of the Commissioner for 1870, and in the same report there is a most interesting account of the grasses of the plains and of the eastern slope of the Rocky Mountains. Several of the more important species, including big blue stem, the various grammas, bromes, and fescues are described, and their apparent value commented on. It is claimed that the big blue stem (*Andropogon provincialis*, fig. 5), together with the little blue stem (*Andropogon scoparius*), formed 60 per cent of the grass flora in the Missouri River region and 26 per cent of the grasses in the Rocky Mountain region. The paper in the report of 1870 appears to be the first that treated exclusively of the grasses of the region mentioned from an economic standpoint, and the grasses then noted as being of most value are those attracting most attention to-day.

GRASS AND FORAGE PLANT INVESTIGATIONS.

As early as 1878 Dr. Vasey, the Botanist of the Department of Agriculture, published in the reports of the Commissioner illustrated papers on the grasses and forage plants of the country, and during the entire period of his service, from 1872 to 1893, he continued to give much attention to the subject and to devote much effort to promoting the interests of economic agrostology.

The unwise management and overstocking of the rich grazing lands of the West have forced upon the farmers of that section the necessity of giving attention to the cultivation of forage crops or at least making an effort to preserve those grasses which have not already been destroyed. The cattle ranges of the Southwest were the earliest to suffer from overstocking, and it was to this region that the Department of Agriculture first directed its attention along lines of grass and forage-plant investigations. In 1886 the Botanist of the Department drew attention to the enormous loss of cattle in the Southwest through overstocking of the ranges and lack of protection from storms in winter. In Bulletin No. 3 of the Division of Botany, published early in 1887, there was presented a report on certain grasses and forage plants for cultivation in the South and Southwest. In this report we find lengthy accounts of carpet grass, hairy-flowered Paspalum, guinea grass, crab grass, Texas millet, etc. This was the first work of the kind published by the Department, and owing to the very complete and practical treatment of the subject, it at once excited a good deal of interest among the farmers and ranchmen of the region it was designed to cover; and it set them to thinking about improving their hay lands and pastures. During the year 1887 the Botanist carried on field investigations through western Texas, New Mexico, Arizona, Nevada, and Utah, the results of which were published in Bulletin No. 6 of the Division of Botany. An enumeration of the grasses of Texas was published in 1890 in Vol. II of the "Contributions from the U. S. National Herbarium." The most comprehensive economic work

published by the Department on grasses and forage plants was issued in 1889 under the general title of the "Grasses and forage plants of the United States, by Dr. George Vasey, with an appendix, giving the chemical composition of grasses, by Clifford Richardson." This work contains 114 full-page plates, illustrating the various grasses and forage plants described, and is essentially a revised and enlarged edition of a similar report published in 1884, under the title "Agricultural grasses of the United States."

During the year 1888 the results of the investigations in the arid regions the two previous seasons bore fruit in the way of securing from Congress an appropriation for the establishment of a grass experiment station at Garden City, Kans. This was the first effort of the kind receiving governmental support. The tract selected for this station contained 240 acres, and experiments were carried on there for five years, from 1888 to 1893. The results accomplished were on the whole satisfactory, and were given in detail in the Reports of the Secretary of Agriculture for 1891, 1892, and 1893.

There have been a number of works on grasses and forage plants published by private enterprise during the last half of the present century. These works, being widely read, have played no insignificant part in diffusing a knowledge of the plants of which they treat, and doubtless they have had a direct influence in improving American agriculture. Among the more important of these publications, the following may be mentioned: "The grasses of Wisconsin," by Dr. I. A. Lapham; "The grasses and forage plants of Tennessee," by J. B. Killebrew, published in 1878; "Grasses and forage plants," by C. L. Flint, an illustrated work of nearly 400 pages; "A handbook of the grasses of Great Britain and America," by J. Henderson; "Farmer's book of grasses and other forage plants for the Southern United States," by D. L. Phares; "Grasses and their culture," by J. S. Gould, 212 pages and 74 plates, published in the Report of the New York Agricultural Society for 1869; and the first volume of Beal's "Grasses of North America," which includes chapters on the physiology, composition, selection, improving, and cultivation of grasses and clovers.

During the past twenty years great progress has been made in the introduction of new forage plants and improved methods of forage production and feeding. Probably the greatest advance has been made in the use of silage and soiling crops and in the increased production of leguminous plants. The agricultural press of the country, the numerous publications of the State experiment stations, and the various bulletins and reports issued by the Department of Agriculture, have all helped to bring about these improved conditions, until to-day our country leads all others in the art of applied agrostology.

ESTABLISHMENT AND WORK OF THE DIVISION OF AGROSTOLOGY.

A new impetus was given to the work of applied agrostology in the United States by the establishment, in 1895, of a division in the

Department of Agriculture devoted exclusively to the investigation of grasses and forage plants. The recommendation for the establishment of such a division was made by the Secretary of Agriculture in his Annual Report to the President for 1894, as follows:

The forage interests in the United States are vast in value. Seventy million tons of hay are cut and cured each summer. This crop is taken from 50,000,000 acres of land. Each year's hay crop is estimated to be worth \$600,000,000. No accurate means have been found for ascertaining the cash value of grasses upon pasture and other lands that are grazed. It is known, however, that these lands support and fatten vast herds of cattle, sheep, and horses. In 1890 such ranges in the United States fed 14,059,030 head of domestic animals. As these millions of animals subsist largely upon native grasses and other forage plants, the magnitude of these figures elucidates the vital necessity of securing, if possible, new and better forage plants in this country. * * * Therefore * * * it is proposed to create a new division in this Department [Agriculture], as provided in the estimates submitted herewith, to be called "The Division of Agrostology." * * * If the hay production in the United States, as a result of this effort in behalf of agrostology, is raised only 1 per cent, it is equal to an increase of \$6,000,000 per year in the value of this single farm product.

The law passed by Congress, in accordance with the above recommendation, establishing the Division of Agrostology, provided for field and laboratory investigations relating to the natural history, geographical distribution, and uses of the various grasses and forage plants and their adaptability to special soils and climates; the establishment and maintenance of experimental grass stations; the collection of seeds, roots, and specimens for experimental cultivation and distribution; the preparation of drawings and illustrations for special purposes, as well as illustrated circulars of information, bulletins, and monographic works on the forage plants and grasses of North America. This law authorized work along technical, or systematic, lines, as well as lines of applied, or economic, agrostology. It made possible greater concentration of purpose and more systematic effort than had before existed, and gave due recognition to an agricultural subject of the greatest importance to the entire country. It afforded means for a wider distribution of the knowledge already gained by the Department and the State experiment stations, and rendered possible the undertaking of new lines of research and closer cooperation with experiment stations and individuals in future investigations. Immediately upon the establishment of this new Division, plans were laid for a vigorous and systematic prosecution of the work along the lines indicated in the act of Congress. In a country of such vast extent and varied character as the United States, there were necessarily many problems relating to the forage supply that demanded the attention of the Agrostologist, and the range of investigations, embracing both purely botanical work and the more practical questions relating to methods of cultivation, adaptation of varieties to local conditions, and the factors governing the forage supply of the different sections of the country, opened a broad and interesting field of labor.

INVESTIGATIONS IN THE WEST.—One of the first subjects to engage the attention of the Agrostologist was the cause of the depletion of the Western stock ranges and the best means of restoring the grasses which had been destroyed by overstocking. Preliminary work was at once undertaken through studies in the field and by the establishment of grass gardens at Washington, D. C., and elsewhere, and by instituting cooperative work with individuals and State experiment stations. During these investigations the more important regions concerned were visited, leading stockmen and farmers were consulted, and data secured concerning soil and climatic conditions relating to forage problems, distribution and value of the native grasses and forage plants, the existing conditions of the stock ranges, the best methods of growing grasses and forage crops, and other questions pertaining to forage production. It soon became evident that one of the most effective means for ascertaining the best methods of restoring or improving the ranges would be the establishment of stations at typical points, where tests could be made with drought-resisting grasses and forage crops, and where general methods of range improvement could be practiced. Such stations were established in 1898 in Texas—one at Abilene and one at Channing. Another station was carried on at Knoxville, Tenn., in cooperation with the experiment station of that State, and early in 1899 arrangements for cooperative work with the experiment station of South Dakota were effected, and a station established at Highmore. Other station work has been done in cooperation with Western railroads at points in eastern Washington.

The field investigations carried on by the Division in the West have been in the States of Montana, Wyoming, Colorado, the Dakotas, Nebraska, Iowa, and Texas. From this work in the West, which is still being carried on, the following publications have directly resulted: "Grasses and forage plants of the Rocky Mountain region," Bulletin No. 5; "Grasses and forage plants of the Dakotas," Bulletin No. 6; "Grasses and forage plants of Iowa, Nebraska, and Colorado," Bulletin No. 9; "Grasses and forage plants of Central Texas," Bulletin No. 10; "Grasses and forage plants and forage conditions of the Eastern Rocky Mountain region," Bulletin No. 12; "The Red Desert of Wyoming and its forage resources," Bulletin No. 13; "Grazing problems in the Southwest and how to meet them," Bulletin No. 16, and Circulars Nos. 21 and 23, the former being the first report on the experiments at Highmore, and the latter dealing with the results of the work at Abilene.

GRAZING AND FORAGE PROBLEMS IN THE SOUTH.—The grazing and forage problems in the South are of great importance. Keen competition is forcing the planters to adopt more diversified systems of agriculture. Four hundred species of grasses occur in the Southern States, and there are broad areas in these States which may profitably be devoted to meadows and pastures. While investigations have

been going on in the West, a study of those grasses most likely to succeed and at the same time meet the needs of stock raisers and dairymen in the South has been made a feature of the work of the Division, particular attention having been given to the native forage plants and the best methods to be employed in maintaining or improving the existing pastures and forage supplies. In cooperation with the experiment station at Knoxville, Tenn., already referred to, trial cultivation of many varieties of grasses and other fodder plants has been made. Field work has been carried on in the States of Mississippi, Louisiana, Alabama, Georgia, Florida, North Carolina, and South Carolina, and a large amount of material of both botanical and practical interest has been gathered by direct observation or through correspondence. Several bulletins bearing upon this work have been published. The first bulletin issued by the Division was "Notes on the grasses and forage plants of the Southeastern States," and the following is taken from the introduction to this bulletin:

Very few plants are widely cultivated in the South for hay or pasturage, the farmer relying for the most part upon the wild grasses. These may be roughly divided into two classes, the first comprising introduced grasses, mostly annuals, which spring up on cultivated land after the regular crops have been removed; the second, native grasses, the majority perennials, which make the bulk of the pasturage. Of the first class, by far the most important, is crab grass (*Panicum sanguinale*), which forms a great part of the volunteer hay crop of the South Atlantic and Gulf States. With it are often associated crowfoot or barn grass (*Eleusine indica*), little crowfoot (*Dactyloctenium ægyptiacum*), pigeon grass (*Setaria glauca*), and, in the far South, spur grass (*Cenchrus echinatus*), and Mexican clover (*Richardsonia scabra*). Of the native, perennial grasses, perhaps the most important belong to the genus *Paspalum*, Louisiana grass (*Paspalum platycaule*) being the most common and best known. *Panicum serotinum* is also a valuable pasture grass over extensive areas. The broom sedges (*Andropogon* species), early in the season, make the bulk of the grazing on thin, dry soils. Three other widely known forage plants, belonging to neither of these classes, must be mentioned. Johnson grass, dreaded as a weed, yet esteemed as a forage plant, is an introduced perennial grass, highly valued for hay. Japan clover (*Lespedeza striata*) is perhaps the most valuable pasture maker, for the largest area, in the Southern States, while both for hay and for grazing Bermuda is king among grasses throughout the South.

Other publications relating to the work done in the South are "Forage plants and forage resources of the Gulf States," Bulletin No. 15, published in 1896; and "Southern forage plants," Farmers' Bulletin No. 102, published in 1899.

INVESTIGATIONS ON THE PACIFIC SLOPE.—The grasses and forage plants of the great region west of the Rocky Mountains, constituting the Pacific slope, have from time to time received some attention from the Department of Agriculture, but the first systematic work of investigating the plants of that region was begun in 1898, when the Agrostologist visited the more important localities, noting the physical conditions of the soil and natural forage resources. Throughout the drier sections east of the Cascades the capacity of the cattle

ranges has been much reduced through drought and overstocking and the forage problems there are very similar to those in western Texas and Wyoming, and can be met by similar methods. Experimental work with grasses and forage plants was begun in 1898 in cooperation with the Northern Pacific Railroad and the Oregon Railroad and Navigation Company. The preliminary report on this work has been published as Circular Nò. 22 of the Division of Agrostology.

SPECIAL INVESTIGATIONS.—Aside from the general work of investigation of grasses in their relation to the forage supply of the country, special studies have been made on individual species, such as cow-peas, sorghum, millets, saltbushes, vetches, etc., concerning which special papers or reports have been issued by the Department. Investigations have also been carried on relative to the adaptability of grasses to special uses, such as the formation of lawns, the binding of soils subject to wash, and the holding of drifting sands. Careful studies have been made of the grasses used in various parts of the country for lawns, and the results of this work were published under the title of "Lawns and lawn making" in the Yearbook of the Department for 1897. The question of texture and color, so important in the making of a perfect lawn, were discussed in that paper, and illustrations introduced showing diversity of texture between several varieties of grasses which have been used as lawn grasses. In the United States there are long stretches of country bordering the Atlantic and Pacific coasts, and even along the shores of the Great Lakes, which are covered with drifting sands. These shifting sands are not confined to the shores of these great bodies of water, but frequently occur along the river banks and at various points in the interior of the country. In some cases the drifting of these sands is a serious menace to profitable agriculture, and along the coasts and rivers there is often danger to navigation, resulting from the shifting of large bodies of sand by the winds or waves. A few grasses have been found which may be utilized in effectually binding these shifting and destructive sands. The results of the discoveries and investigations made along these lines were published in the Yearbook of the Department for 1898 in an illustrated article on "Sand-binding grasses." One of the most recent discoveries of the Division in the way of sand-binding grasses is the seaside blue grass (*Poa macrantha*), which grows in the sands along the Pacific coast of Oregon and Washington, where it is often seen covering the summits of the highest dunes. It is an excellent sand binder, and possesses the advantage over beach grass in having more tender leaves and stems, which render it of value for grazing. It has the habit of sending out slender lateral branches, which, lying prostrate on the sand, extend 4 to 6 feet or more from the parent stock, and as these readily develop roots at the joints, the grass is rapidly propagated over considerable areas. If available for cultivation in the interior, seaside blue grass will prove a most valuable acquisition

for cultivation in very sandy soils. The important subject of forage plants for cultivation on alkali soils is discussed in a paper from the Division in the Yearbook of the Department for the same year (1898), and in the Yearbook for 1895 is a paper on the "Grasses of salt marshes," the result of a previous year's investigation of the marshes along the coasts.

SOME VALUABLE GRASSES AND FORAGE PLANTS.—Some of the grasses and forage plants which the Division of Agrostology has recommended or to which special prominence has been given in its experimental work on account of their value for agricultural and other purposes are here given, as follows:

Blue grasses.—The blue grasses, of which Kentucky blue grass (*Poa pratensis*) may be considered the type, are among the most valuable species for pasturage, and some of them are unexcelled for hay. Kentucky blue grass is useful for both purposes, and is one of the most widely distributed species of the genus. In the United States it ranges from Maine to the Gulf, westward to the Pacific Ocean, and northward to Alaska. Some of the forms present qualities of unusual excellence, and the Division is giving attention to the selection of these for improving our forage supply. In the Rocky Mountain region are many species of *Poa*; a few of these the Division has experimented with to some extent, and so far quite satisfactory results have been secured, Wyoming blue grass (*Poa wheeleri*, fig. 6) being found one of the best. Its habit of growth is not unlike that of Kentucky blue grass, but it is probably much better able to survive long periods of drought than is that species. Smooth bunch grass (*Poa levigata*) is another species of the blue-grass class common in the Rocky Mountain region. Mutton grass (*Poa fendleriana*) is one of the best grasses of the mountain



FIG. 6.—Wyoming blue grass (*Poa wheeleri*): a, empty glumes; b, c, florets.

ranges of New Mexico and Arizona. Nevada blue grass (*Poa nevadensis*) is a fine variety occurring in the Rocky Mountain regions of Montana and Colorado, some forms of it extending westward to the Cascades. It promises to be a very productive hay grass, and trials are being made with it having that in view. Sand blue grass (*Poa leckenbyi*) is a newly discovered species of eastern Washington, and is remarkable in growing in almost pure sand under

conditions where the well-known Eastern grasses would fail entirely. It is hoped that this grass will prove to be not only a good sand binder but a good grass for very sandy soils and sandy areas in which other crops have failed. It is undoubtedly an excellent sand-binding species, and if it finally proves successful in the interior it will serve the double purpose of holding drifting sands and furnishing excellent forage.

Lyme grasses.—The lyme grasses present a number of varieties of special interest, and seeds have been collected of several of them. In some sections, Canadian lyme grass, or a form referable to that species, promises to be a most productive hay grass. It has been tried by the Division in Texas and at the stations in the Northwest. Woodland lyme grass (*Elymus*



FIG. 7.—Western wheat grass (*Agropyron spicatum*): a, empty glumes; b, florets.

glaucus) is a common grass in Montana, Washington, and Oregon, and promises to be of some agricultural value. Giant lyme grass (*Elymus condensatus*) is a tall, rank-growing species of the Pacific slope, extending eastward to Montana. It is one of the dry-land grasses, and may prove of considerable value for hay or grazing in the drier regions of the Northwest. Yellow lyme grass (*Elymus flavescens*) and small sand lyme grass (*Elymus arenicolus*) are species of Oregon and Washington which are excellent natural sand binders. Along the Columbia

River the spontaneous growth of the sand lyme grass has in many cases effectually checked the drifting of the sands which are blown out from the river bed. Both of these species deserve careful consideration by those who are endeavoring to prevent the blowing of destructive sands.

Wheat grasses.—The wheat grasses are characteristic grasses of the Northwest. Western wheat grass (*Agropyron spicatum*, fig. 7), known to many of the ranchers as bluestem, is one of the best native grasses for hay, and efforts are being made to extend its cultivation. Meadow wheat grass, a closely allied species, is also a promising native variety. Bunch wheat grass (*Agropyron divergens*) may be classed as first among the dry-land species. It grows naturally in exceedingly dry soils and where the annual rainfall is very light. This wheat grass and the two feather grasses (*Stipa viridula* and *Stipa comata*), common to the same region, are the most promising species for regrassing the overstocked ranges.

Blue grama and side-oats grama.—Blue grama (*Bouteloua oligostachya*), known also in some sections of Montana as buffalo grass, is one of the pasture grasses among our native species. It is readily propagated by seed and thrives in almost any soil. It has been grown at all of the stations and by many volunteer experimenters. It apparently does as well in Washington, D. C., in the heavy clay soils as in the light and dry soils of eastern Washington. Side-oats grama (*Bouteloua curtipendula*) has a wider natural range, and although making a turf inferior to that of blue grama, it is nevertheless an excellent pasture grass, and under favorable circumstances yields an abundant hay crop.

Fescue grasses.—The mountain districts afford many native species

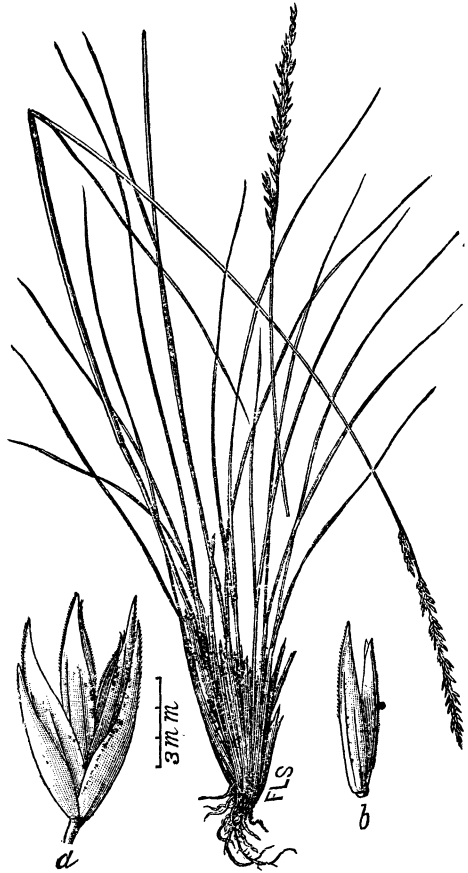


FIG. 8.—King's fescue (*Festuca kingii*): a, spikelet; b, floret.

of fescues. Creeping fescue and sheep's fescue exist in many varieties, some of them possessing great points of excellence. Aside from these two species there are others of equal value. King's fescue (*Festuca kingii*, fig. 8) is one of these. It is a native of Colorado, and it has been successfully propagated by seed, which it yields abundantly. Buffalo bunch-grass covers extensive meadows in Montana, affording excellent grazing, and is occasionally cut for

hay, being very productive. It grows to the height of 3 or 4 feet, and its introduction into agriculture will be a test of its merits under cultivation.

Brome grasses.—Native brome grasses are well worth more attention than has been given them. They seed abundantly, the seed is easily harvested, and germinates readily. The Division of Agrostology has tried several of the Western species, and from the limited experiments made, it is evident that there are important grasses in this group. *Bromus pumpellianus*, a native of Montana, Colorado, and Wyoming, is hardly to be distinguished from the European smooth brome (*Bromus inermis*, fig. 9), the introduction of which has done so much to improve the stock interests of the country.

The above list might be greatly extended, for there

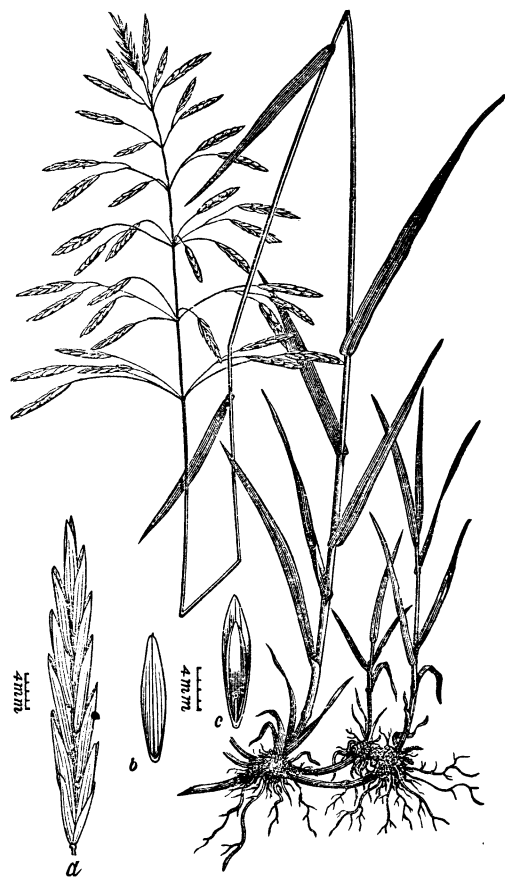


FIG 9.—Smooth brome grass (*Bromus inermis*): a, spikelet; b, flowering glume seen from the back; c, floret seen from the anterior side, showing palea.

are many species as deserving of notice as those here mentioned. Bulletin No. 14 of the Division of Agrostology treats of the economic grasses and gives an extended list of the same.

Forage plants.—There are many forage plants which do not belong to the order Gramineæ. The greater proportion of these, and those which are generally regarded as the most valuable, belong to the Leguminosæ, or family of legume-bearing plants, which includes the

clovers, vetches, beans, peas, lupines, etc. There are seventy varieties of native clovers, ninety lupines, forty vetches, and half as many wild beans, from among which doubtless selections can be made of varieties possessing special qualities superior to any of those now cultivated.

The leguminous forage crops, which now play such an important part in agriculture, were made the subject of a paper from the Division in the Yearbook for 1897. The cultivation of these plants is increasing every year, and their great value as soil renovators and cheap producers of fodder, rich in nitrogenous compounds, is becoming more and more widely known and appreciated. Referring briefly to the history of the cultivation of these plants, the writer of the paper in question states:

The oldest cultivated forage plants and the best for enriching the soil are those of the clover family. Not one of the now well-known hay or pasture grasses has been cultivated more than three hundred years, while a number of leguminous crops have been grown for forage from prehistoric times. The chick-pea, or gram, dates back full thirty centuries. It is to-day one of the leading grain crops and soil renovators of Spain, India, and central Asia.

Alfalfa, which is recognized as the best forage plant in the semiarid Western States, or wherever dependence must be placed upon irrigation, was cultivated by the Romans at least two hundred years before the commencement of the Christian era. The soy beans have been grown in China and Japan and lentils in Hungary from prehistoric times. The field pea, originally from northern Italy, was introduced into cultivation eight or ten centuries ago. Sainfoin was grown in France and red clover in Media during the early years of the fifteenth century, and white, or Dutch, clover in Holland at the beginning of the eighteenth century. Sulla, which is largely grown in southern Italy and northern Africa, and which seems to be admirably adapted to well-drained soils in Florida and the Gulf States, was first introduced into cultivation in 1766. The cowpea has been known in this country nearly as long as sulla. Alsike, or Swedish clover, was taken up as a forage about thirty years later, while during this century and within recent years a score or more of valuable legumes have been brought to the attention of the farmer, and hardly a year passes that new ones are not added to the list.

One of the most recently introduced and promising of the leguminous plants is the velvet bean, a native of India. Its range of profitable cultivation is limited to the Southern States. The velvet bean is fully described and illustrated in Circular No. 14 of the Division of Agrostology.

The saltbushes of this country are very numerous in variety and often cover extensive areas in the far Western States and Territories. Their value to the stockmen of the West is clearly set forth in Bulletin No. 13 on the "Red Desert of Wyoming and its forage resources," and a number of both the native and introduced species are described in Farmers' Bulletin No. 108, which is devoted exclusively to them. It is only within the last few years that the forage value of these plants has been recognized in this country, and their importance in increasing our forage supply is fully treated of in a paper on "Forage

plants for alkali soils," in the Yearbook for 1898, as already noted. It is for reclaiming or rendering valuable for grazing purposes soils highly impregnated with alkali that these plants are especially useful. The following is from the paper just referred to:

The saltbushes and salt sages, both introduced and native, have proved to be of value in all alkali-impregnated soils. A more extended cultivation of saltbushes is recommended throughout the West, and while trials are being made with the Australian species, the native forms, many of them being fully as leafy and having as succulent herbage, should not be overlooked. It is probable that quite a number of the thirty or more salt sages and saltbushes that grow wild on the high plains, mesas, and deserts of the West would, if only given an equally favorable opportunity, prove to be as well adapted to cultivation as any of the foreign species. As the West is developed the amount of grazing land is each year decreasing and the extensive areas of alkali-impregnated soils are becoming more valuable. The increase of these soils in value in the estimation of the Western cattle growers will come through the use of saltbushes and other alkali-tolerant forage plants.

Through the Division of Agrostology the Department has distributed the seeds of a number of the native saltbushes and quantities of several of the Australian species, the one receiving the most attention being the Australian saltbush (*Atriplex semibaccata*). Seed of this species was introduced into this country nearly twenty years ago by the California experiment station at Berkeley, but it has been only within the last year or two that it has received any widespread attention. During the present season large quantities of the seed have been distributed by the Secretary of Agriculture in regions where this saltbush is likely to prove most useful in the way of increasing the forage resources of our country.

VOLUNTEER EXPERIMENTERS.—Much of the work done by the Division of Agrostology in testing the adaptability of varieties to the prevailing conditions in different sections of the United States has been carried on in cooperation with farmers and stockmen as well as with a number of State experiment stations. These tests or experiments have been made chiefly by sending the experimenters seeds of the grasses or forage plants which have been collected or obtained by purchase, and requesting that reports be made as to the success or failure of the attempts made to grow them. Nearly ten thousand packages of seeds, including two hundred and fifty-five varieties, have been sent out in this way to those expressing their willingness or desire to cooperate with the Division. The reports received on account of this method of seed distribution during the past three years have been prepared for publication as Bulletin No. 22, which will serve to illustrate very well what can be accomplished in acquiring a practical knowledge of grasses and forage plants through volunteer experimenters. These experiments have proved of great value, not only as being the means of finding out the suitability of varieties for cultivation in different sections of the country, but also of bringing

the work of the Division in closer touch with the people whom it is designed to serve. The results of these tests have shown that many of the valuable native grasses adapt themselves readily to cultivation, and have also demonstrated the value of some of the newly introduced varieties, as well as the possibility of a wider cultivation of many of those already commonly grown in the United States. Thus, it has been discovered that slender wheat grass and a number of the native bromes and blue grasses can be utilized in the formation of artificial meadows and pastures; that other of the wheat grasses, the grama grasses, blue grasses, and native fescues may be utilized in reclaiming the worn-out ranges in the drier sections of the country; that smooth, or Hungarian, brome grass, recently introduced from the Old World, is a most valuable hay and pasture variety for the drier sections of the West and Northwest; that Australian saltbush, as well as a number of native saltbushes, is well adapted to cultivation on lands strongly impregnated with alkali, such as are found in many parts of the Southwest; and the experiments now in progress seem likely to demonstrate the value of other varieties in certain sections, such as oasis alfalfa for the hot, dry Southwest, and Turkestan alfalfa for the dry sections of the Northwest where the climate is colder.

SOME RESULTS OF WORK OF DIVISION OF AGROSTOLOGY.—The Secretary of Agriculture, in summing up the work of the Division of Agrostology in 1898, said:

Through the efforts of this Division we are learning the needs of the several sections of the country and the forage problems they have to meet. We are acquiring a better knowledge of the distribution and value of our native grasses and forage plants, as well as the peculiar conditions of soil and climate best suited to their growth.

The discovery of new economic grasses or new and valuable forage plants, the adaptability of the native species to cultivation, the introduction of forage plants into new or untried regions, the application of species to new or special uses, and the general diffusion of knowledge through publications and correspondence respecting these plants are among the important results of the work of the Division.

EXTENSION OF INVESTIGATIONS.—Through the Division of Agrostology the Secretary of Agriculture is working not only to produce more and better hay on every acre of meadow land, but also to preserve or improve the great cattle ranges of the West and the pasture lands of the whole country. In the Report of 1899, the Secretary says:

The investigations under way in the Gulf-coast region and on the Pacific slope ought to be extended in their scope; the work on range improvement should be continued along the present practical lines; the investigations looking toward the preservation and improvement of our most valuable native grasses and forage plants should be continued; the study of soil and sand-binding grasses ought to be extended to include experiments as to the adaptability of our native sorts to practical use for fixing the shifting sands of our coasts and for holding embankments in place, as well as to the introduction of desirable foreign sorts; investigations relative to the introduction, cultivation, and management of improved

pasture and forage crops on the worn-out farms of the East should be undertaken; the question of forage crops suitable to alkali soils is one of much importance to certain sections of the country, and should receive full and careful investigation.

APPLIED AGROSTOLOGY IN THE STATE AGRICULTURAL EXPERIMENT STATIONS.

Nearly all the State experiment stations, ever since their organization in 1887, have given more or less attention to the subject of grasses and forage plants, and a few of them have made this a leading feature of their work. Among the first to undertake work along these lines was the California experiment station at Berkeley, and this station, under the direction of Prof. E. W. Hilgard, has done very much toward the introduction of valuable forage plants into that State by the distribution of seeds of many varieties. Other stations which have given special attention to grass and forage-plant investigations are those in Nebraska, South Dakota, Tennessee, Mississippi, Alabama, Ohio, Connecticut (Storrs), Kansas, Michigan, New York, Minnesota, and Massachusetts.

Over two hundred bulletins and reports have been issued by the several stations on the subject of grasses and forage plants—a fact which in itself demonstrates the great interest taken in these investigations and the manifest importance attached to the subject. Some of the stations have published descriptive and illustrated grass floras of the States in which they are located, which have done much toward disseminating a knowledge of grasses and inciting greater interest in the improvement of forage resources. One of the most complete and elaborate of these floras is that published by the Tennessee station, in which all the grasses known to occur within the State are illustrated.

The effect of the grass and forage-plant investigations which have been carried on by the Department of Agriculture during recent years, together with similar investigations at the different State experiment stations, is seen at the present time in the changed methods of farming that are being practiced in many sections of the country. This is well illustrated in the South, where but a few years ago it was thought by many that the better cultivated grasses and forage plants could not be successfully grown. It is also illustrated in the improved methods of handling pastures and ranges that are coming into practice in many parts of the West, and in the greater diversity of the grass and forage crops that are grown in almost all sections of the country where dairying is a leading industry.

SCIENTIFIC, OR SYSTEMATIC, AGROSTOLOGY.

At the beginning of the century the number of known North American grasses barely exceeded one hundred species. These had been published chiefly in the works of Linnæus, Lamarck, and Walter. In 1803 Michaux published his "*Flora Boreali Americana*," in which he

describes as new sixty-eight species. Michaux's work was soon followed by those of Persoon, Pursh, Nuttall, Muhlenberg, Elliott, and Beauvois, in which many new North American species were published. Beauvois, in his "*Agrostographiæ*," undertook to establish a natural arrangement of the whole Gramineæ, with descriptions of the genera then known, together with many new ones, some of which were North American, and the majority of which have since been adopted. Between 1820 and 1850 appeared the great works of Kunth, Trinius, and Nees von Esenbeck, in whose writings, especially those of Trinius, who confined himself exclusively to grasses, many North American species were published for the first time. It was during this period that the great American botanists, Drs. John Torrey and Asa Gray, did much to advance our knowledge of North American plants, and many new species of Gramineæ appear in their various works. These authors, especially Dr. Gray, whose publications continued until a comparatively recent date, made further additions to agrostological science, and their works are essential to the student of grasses to-day.

Steudel in 1855 published the first volume of his "*Synopsis Plantarum Glumacearum*," which contains a general enumeration of the grasses of all countries, and is the last work in which such an enumeration has been attempted. All the older North American species are included, and Steudel describes many new ones, some few of which are still retained.

The knowledge of Southern grasses was greatly advanced by the publication of Chapman's "*Flora of the Southern United States*" in 1862. Grisebach, in his "*Flora of the British West Indies*," published in 1864, described a number of species which come within our southern limits, and in Ledebour's "*Flora Rossica*," which appeared in 1853, many species common in Alaska are published for the first time. In England, General Munro was for many years the leading authority on grasses, and in this country Dr. George Thurber was the court of last resort in all pertaining to American grasses. The chief contribution to agrostology made by the former was his monograph on the tribe *Arundinariæ*, and the latter is best known to the student of grasses to-day by his contribution to Brewer and Watson's *Botany of California*, published in 1880, in which all the species of that State then known were fully described.

A marked impetus was given to the study of grasses by English-speaking students by the publication of Bentham's "*Notes on grasses*," in 1881, in the *Journal of the Linnean Society*. In this work the several tribes and genera are discussed. The classification presented is essentially based upon the opinions of General Munro and finally adopted in the third volume of Bentham and Hooker's "*Genera Plantarum*," published in 1883. A work of much interest to the student of the grasses of the Southwest is Fournier's "*Gramineæ*" in his "*Enumeration of Mexican plants*," published early in the last decade. It is

the only work especially devoted to the grasses of Mexico, and includes many species occurring in the States and Territories bordering that country. After the death of General Munro, in 1880, Prof. E. Hackel, of St. Poelten, Austria, was at once recognized as the highest authority on grasses, and his contribution to the great German work on the "Natural families of plants," by Engler and Prantl, is ample evidence of his right to the position. An American translation of this work, under the title of "The true grasses," published in 1890, has done much to promote the study of systematic agrostology in this country. It presents in a clear and concise manner the general features of the grass family, enumerating the best-known economic species, discussing their structure and morphology, and their arrangement into tribes and genera, thus placing in the hands of the American student a manual by which he is enabled to classify any grass which may come into his hand, and materially assisting the systematic study of grasses, which now forms such an important feature in the curriculum of nearly all our agricultural colleges.

In 1889 Hackel published an extensive monograph of the *Andropogoneæ*, in which all the North American species of that tribe then known are fully described, a few of which are presented as new to science. The system of classification of the tribes and genera of the *Gramineæ* presented by Hackel in his "True grasses," and now generally adopted in this country, was much modified by Baillon in his "*Monographie des Graminées*," published in Paris in 1893. This is the latest general treatment of the grass family as a whole that is of special interest to the student of American grasses. In this work not only is there a decided modification in the limitation and arrangement of the tribes and genera from that proposed by Bentham and by Hackel, but an attempt is made to adopt the more advanced system of nomenclature.

Four years ago, in 1896, Prof W. J. Beal, of the Michigan Agricultural College, published the second volume of his work on the "Grasses of North America," wherein are brought together for the first time descriptions of all the North American species known to the author. He enumerates over one thousand three hundred species, including many from Mexico and Central America, with full descriptions. No other single publication covers the same extended field.

SYSTEMATIC AGROSTOLOGY IN THE DEPARTMENT OF AGRICULTURE.

While the Department of Agriculture has always been more or less active in promoting the interests of applied agrostology, it has in later years been hardly less energetic in advancing scientific knowledge of grasses and developing a wider interest on systematic lines. Immediately following the publication of the third volume of Bentham and Hooker's "*Genera Plantarum*," already referred to, Dr. George Vasey, then Botanist of the Department, published as a special report a list of the grasses of the United States, together with a synopsis of the tribes and genera, which were chiefly translated from Bentham

and Hooker's work. Two years later, in 1885, a revised and somewhat enlarged edition of this list was published under the title of "A descriptive catalogue of the grasses of the United States." This work included many economic notes, and was prepared with the view of assisting both the scientific student and the farmer. Between the years 1891 and 1893 the Department published two volumes prepared by Dr. Vasey, containing descriptions and full lithographic plates of two hundred species of grasses belonging to the region of the Southwest and the Pacific slope. The illustrations in this work are for the most part excellent and the descriptions are very full. The plan adopted is not unlike that of Trinius's "Icones," and it is a matter of regret that the work could not have been continued until all of the American species were illustrated in the same manner. In 1892 Dr. Vasey published as Part I to Vol. III of the "Contributions from the U. S. National Herbarium" what he designated as Part I of a "Monograph of the grasses of the United States." Following the classification of Prof. Edward Hackel this part contains descriptions of all the North American species of grasses known to the writer through the subtribe Phleoideæ in the seventh tribe Agrostideæ. At the time of his death (March 4, 1893), Dr. Vasey had prepared the manuscript of a considerable portion of the second part of this monograph, but the work in the form in which it then appeared has not been continued. During the years between 1881 and 1893 Dr. Vasey published many new species of North American grasses, not only in the bulletins issued by the Department, but in the leading botanical journals and in the proceedings of scientific societies. The total number of species published by him between 1885 and the time of his death was one hundred, and nearly as many new varieties.

Since the establishment of the Division of Agrostology in 1895, systematic work on grasses has been continued by the Agrostologist and his assistants. Papers which may be classed as belonging to systematic agrostology have been published in Bulletins Nos. 4, 7, 8, 11, 17, 18, 19, and in Circulars Nos. 9, 10, 15, 16, and 19 of the Division. Circular No. 15, published July 14, relates to "Recent additions to systematic agrostology," while the other circulars referred to contain chiefly descriptions of new species. Under the general title "Studies on American grasses," to which Bulletins Nos. 4, 8, 11, and 18 belong, there have been published revisions of certain North American genera and enumerations of species collected in the little-known regions, and a large number of species presumably new have been described. In Bulletin No. 19 there was published a very carefully prepared paper on the structure of the seeds of grasses, the investigations being made largely with the view of establishing a basis of classification upon the Caryopsis. Six hundred and twenty-seven North American grasses are figured and described in Bulletins Nos. 7 and 17. The illustrations in these two bulletins are all drawn from original material and form a part of a series which, when complete, will illustrate all of our North American grasses. The Agrostologist has also published in

botanical journals and in proceedings of scientific societies many papers bearing on the subject of systematic agrostology, notably among these may be mentioned "Notes on the grasses in the Bernhardt Herbarium, collected by Thaddeus Haenke and described by J. S. Presl," published in the Tenth Annual Report of the Missouri Botanical Gardens. This paper is illustrated by fifty-four plates, drawn from the types of species described by Presl in "*Reliquiæ Haenkeanæ*." In these various papers and in the publications of the Division, the Agrostologist has during the last five years published one hundred and twenty-five species and thirty-three varieties.

A good herbarium or collection of grasses forms an essential part—is, in fact, the basis of all work in systematic agrostology. The Division of Agrostology, since its organization, has been steadily at work building up an herbarium of grasses, until now the collection numbers nearly thirty-five thousand mounted sheets of specimens, more than twenty-five thousand of which have been added during the past five years. This collection, which forms no inconsiderable part of the great National Herbarium located in Washington City, is especially valuable, not only on account of its richness in North American species, but also on account of its containing a great many types of the species published in recent years.

SYSTEMATIC AGROSTOLOGY IN THE STATE AGRICULTURAL EXPERIMENT STATIONS.

It is believed that the work of the Department of Agriculture in the way of scientific investigation of grasses has done much to develop similar lines of work in the agricultural experiment stations. The work at these stations, in order to meet the demands of the people, must of necessity be more along the lines of applied agrostology. Several of the stations have, however, published descriptions of the grasses of the States in which they are located. In 1894 the Tennessee Agricultural Experiment Station published a bulletin in which all the species known to occur within the State were fully described and illustrated. This work contained keys of analysis to the tribes and genera, and in the larger genera to the species also. Less fully illustrated descriptive bulletins have been published by several other stations, but comparatively little original work has been done by any of them along systematic lines. The Division has lent material aid to this work, not only through its several publications, but by the distribution of many thousands of named specimens of grasses to these agricultural experiment stations. As illustrating the attention now paid to systematic agrostology and the rapid progress being made in this branch of the subject, it may be stated that during the last five years three hundred and seventy-four new species of North American grasses and one hundred and sixty-six new varieties have been published.